การประเมินคุณค่าทางอาหารของหญ้าแห้ง โดยใช้ส่วนประกอบทางเคมี

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บทคัดย่อ

อาหารจะมีคุณค่าแก่สัตว์เพียงใดขึ้นอยู่กับจำนวนโภชนะที่สัตว์สามารถนำไปใช้ให้เกิดประโยชน์แก่ร่ายกายได้ ดังนั้นการประเมินคุณค่าอาหารที่ใกล้เคียงกับความเป็นจริงก็ควรจะต้องประเมินจากตัวสัตว์โดยตรง เช่น โดยยารทำ Digestibility Trial ในสัตว์ ซึ่งการกระทำเช่นนั้นต้องใช้เวลานาน และไม่สะดวกในการที่จะประเมินคุณค่าอาหารหลาย ๆ ชนิดในคราวเดียวกัน การหา Digestibility ในหลอดทดลอง (In Vitro) ทำให้สามารถประเมินค่าอาหารหลาย ๆ ชนิดในเวลาเดียวกันได้ แต่ก็ยังต้องใช้เวลาหลายวัน กว่าขบวนการจะสมบูรณ์

วิธีที่สะดวกและง่าย และยังเป็นที่นิยมใช้อยู่ในปัจจุบัน คือ การวิเคราะห์หาส่วนประกอบทางเคมี แล้วใช้ส่วนประกอบทางเคมีนี้บอกคุณค่าของอาหาร ส่วนประกอบที่มักใช้บอกคุณค่าอาหารโดยทั่วไปคือ โปรตีน โปรตีนมีความสัมพันธ์อย่างใกล้ชิดกับจำนวนโภชนะที่ย่อยได้ของสัตว์ ดังนั้นจะเห็นได้ว่าอาหารที่มีโปรตีนมากจะมีเปอร์เซนต์ Digestibility สูง

สำหรับอาหารพวกพืชหญ้า เนื่องจากมีเยื่อไย (Fibre) เป็นส่วนประกอบส่วนใหญ่เยื่อไยจึงมีบทบาทสำคัญยิ่ง โดยเฉพาะสำหรับสัตว์เลี้ยงเคี้ยวเอื้อง ทั้งนี้เพราะสัตว์เคี้ยวเอื้องสามารถใช้ Cell Wall ซึ่งเป็นส่วนประกอบของเยื่อไยได้บางส่วน การประเมินคุณค่าของอาหารสัตว์ประเภทพืชหญ้า จึงต้องนำเอาส่วนประกอบนี้มาร่วมพิจารณาด้วย

รายงานนี้ เป็นผลมาจากการศึกษาความสัมพันธ์ (Correlation) ของ In Vitro Digestibility กับส่วนประกอบทางเคมีของอาหารสัตว์เคี้ยวเอื้อง 2 พวก คือ หญ้าแห้งธรรมชาติ (Hay) และหญ้าซึ่งทำแห้งโดยเครื่องจักร (Artificially Dried Grass) พบว่ามี Correlation ดีพอที่จะใช้ส่วนประกอบทางเคมีบางอย่าง บอกคุณค่าอาหาร (Nutritive Value) ของหญ้าแห้งทั้ง 2 พวกนี้ได้

การประเมินคุณค่าทางอาหารของหญ้าแห้งนี้ อาจทำได้ง่ายและเที่ยงตรงขึ้นโดยวิเคราะห์หาส่วนประกอบทางเคมีอีกพวกหนึ่งคือ Hydrolysable Carbohydrate แล้วนำมาคำนวนแบ่งอินทรีย์วัตถุที่ย่อยได้ (Digestible Organic Matter) ออกเป็นส่วนที่ย่อยง่าย (Easy–to–digest–fraction) และส่วนที่ย่อยยาก (Hard–to–digest–fraction) ซึ่งส่วนประกอบเหล่านี้มี Correlation กับ In Vitro Digestibility สูงเช่นกัน

นอกจากนี้ อัตราการย่อย (Digestion Rate) ของหญ้าแห้งทั้ง 2 พวก ก็มีความแตกต่างกันตามความแตกต่างของระดับอินทรีย์วัตถุที่ย่อยยากของหญ้าแห้งแต่ละพวก ซึ่งความแตกต่างอันนี้น่าจะมีผลมาจากกระบวนการทำหญ้าให้แห้ง และความแตกต่างนี้ดูเหมือนจะมีอิทธิพลต่อการกินหญ้าโดยสมัครใจ (Voluntary intake) ของสัตว์ด้วย

Introduction

There are several methods of determining the value of feedstuffs. Voluntary intake as well as digestible nutrients can both indicate the value of feedstuffs because they are highly interrelated with the total digestible intake, but these methods are not practical when lots of samples are to be evaluated. A more simple one is the method of analysing the chemical composition and considering it in relation to the digestibility.

The composition of feedstuffs, to some extent, tell the differences in their qualities. It is known that as the grasses grow older, the quality is lowered. Crude fibre percentage increases as protein and soluble carbohydrate decrease (Minson 1971, Mowat 1969). In animals fed grasses, crude fibre plays an important role because of its greater fraction. It is especially so in ruminants because they are able to use this hard-to-digest fibre. The content of crude fibre can be determined by the Weende Method but this has certain limitations. Van Soest 1963 a, 1963 b, 1970, carried out the forage fibre analytical methods which are believed to be a better estimation of feed value. The Van Soest methods give an idea of different fractions of cell walls, that is cellulose, hemicellulose and lignin. Tilley and Terry 1963, carried out an in vitro digestibility technique using rumen fluid. They found a close relationship between in vitro and in vivo digestibility. However, the technique has a limitation in that the digestibilities are determined only on the organic matter basis. Van Soest, 1966, also estimated the digestibility of forage by the in vitro digestion of cell walls and found that the values were nearly equal to those of the true in vivo digestibility.

The purpose of this experiment was to find the relationship between the in vitro digestibility and the chemical composition of grasses. Various chemical analytical methods for the determination of nutritive value of hay and artificially dried grass were compared. The relationships between the digestion rate and the chemical composition were also determined.

Experimental Procedures

Dry matter, ash and crude protein were determined by the standard procedure as stated in the AOAC. Crude fibre was determined by the weende method. NFE and crude fat were calculated as DM subtracted by ash, protein and crude fibre. Hydrolysable carbohydrate was determined by the Christensen (1973) procedure. Cell wall fractions were determined by Van Soest methods as NDF, ADF, and acid detergent lignin (ADL) methods for hemicellulose, and lignin. In vitro digestibilities were determined by the Tilley and Terry method as modified by Frederiksen (1966).

chemical compositions and the in vitro digestibilities were calculated as in table 3. The calculations were done for all samples, all samples excluding alfalfa, hay excluding alfalfa and artificially dried grass excluding alfalfa. The correlations seemed to be better for all samples when excluding alfalfa. The reason for excluding alfalfa was because of its markedly different levels of chemical components as compared to the others.

When hay and artificially dried grass were considered separately, most of the correlations with in vitro digestibility were better for artificially dried grass than for hay. For artificially dried grass, the correlation coefficients for crude fibre, hydrolysable carbohydrates (HC), NDF, ADF, cellulose, crude protein (CP) + HC and nitrogen free extract (NFE) + fat + crude fibre (CF) – HC were – 0.90, 0.80, – 0.72, – 0.86, – 0.87, 0.88 and – 0.88 respectively, while the corresponding values for hays were – 0.17, 0.50, – 0.52, – 0.20, – 0.09, 0.38 and – 0.38 respectively. Correlation coefficients for hemicellulose and lignin in percent of cell wall were low in both hay and artificially dried grass. The reason for this variation was not cleared, but it might be due to the nature of the hay or its processing.

Using the common analytical methods, feedstuff compositions were determined by analysing for water, ash, protein, NFE + fat and crude fibre. Most of the correlations between the in vitro digestibility and these fractions were poor. The correlation coefficients of the regressions between CF and in vitro digestibility for all samples, with and without alfalfa were – 0.70 and – 0.73. For NFE + fat, all samples with alfalfa gave a correlation coefficient of 0.68 while the value for the artificially dried grass was 0.61. The best correlation coefficient obtained, – 0.90, was for crude fibre in artificially dried grass alone.

When Van Soest methods were used, the content of NDF, ADF, lignin, hemicellulose and cellulose were determined. The correlations were good except in the case of lignin and hemicellulose. Cellulose, for artificially dried grass alone, had a correlation coefficient of – 0.87, and a value of – 0.68 for all samples without alfalfa. The corresponding correlation coefficients for NDF were also good, being −0.72 and −0.76 respectively. In the case of ADF, three of the four comparisons had high correlation coefficients; the only poor comparison was with hay.

The hydrolysable carbohydrates gave a good correlation with the in vitro digestibility as did both the easy–to–digest fraction (HC + CP) and the remaining fraction. The hydrolysable carbohydrates gave correlation coefficient of 0.82, 0.77 and 0.80 for all samples, all samples without alfalfa and artificially dried grass. The corresponding correlation coefficients for the easy–to–digest fraction were 0.65, 0.76 and 0.88 respectively. The remaining fraction (NFE + fat − HC) which forms a part of the so–called hard–to–digest fraction (NFE + fat + CF − HC) gave correlation coefficients of −0.70 and −0.62 for all samples without alfalfa and artificially dried grass. Moreover, when we put crude fibre together with the remaining fraction forming the hard–to–digest fraction, good correlations were also obtained for all samples, all samples without alfalfa and artificially dried grass (−0.65, −0.76 and −0.88 respectively).

Although the correlation coefficients were high, crude fibre could not be used as an indicator to predict the feed value. The disadvantage of the crude fibre as determined by the Weende method was that it could not express the whole hard–to–digest fraction. Part of it was included in the NFE as the remainder after subtracting the HC fraction.

Van Soest partially removed this unreliability by developing new techniques for the determination of the composition of the cell wall. It can be seen from the work described in this report that the most of his different components gave good correlations with the in vitro digestibility.

Better correlations were obtained when feedstuff components were considered as an easy–to–digest and as a hard–to–digest fraction. Whereas crude protein was poorly correlated with the digestibility the HC were well correlated. When these two values were summated, (forming the easy–to–digest fraction), the combined term was highly correlated. The hard–to–digest fraction, which could be simply calculated, was also well correlated with the digestibility. However, it should be emphasized that good correlations were not obtained in any of the above comparisons for the hay samples.

The in vitro digestibility of all samples was determined after incubation periods of 6, 12, 22, 30, 36, and 48 hrs. (table 1). The digestibilities of hay and artificially dried grass after 48 hrs. were apparently different. Also, the digestion rates seemed to be markedly different. The percentages of the undigested organic matter were calculated at 12, 24, 36 and 48 hrs. see table 4. It can be seen that the artificially dried grasses had higher digestion rates than the hay samples. This had a good agreement and this was generally associated with higher CP and HC contents.

These differences in digestion rates can be seen to be more clearly shown in the times which were required for the digestion of 50% and 75% of the digestible organic matter as is shown in table 4. It can be seen that there was a marked difference between the time used for digestion of 50% digestible organic matter in hay and in artificially dried grass. Hay required twice the time than the artificially dried grass. The same conclusion can be drawn for the 75% level but the differences were not as great. This investigation could help to predict the voluntary intake of hays and artificially dried grasses as it was known that the digestion rate was one of the factors influencing the voluntary intake quite apart from the total digestibility.

Summary and conclusions

Samples were determined for different chemical compositions by means of various analytical methods. In vitro digestibilities were also determined. Regressions and correlation coefficient between the different parameters and the in vitro digestibility were calculated.

From this study it seems possible that the nutritive value of a grass product can be predicted, with some confidence, from its chemieal composition.

The determinatinn of the hydrolysable carb ohydrates and the subsequent partitioning of the digestible organic matter into easy–to–digest ond hard–to–digest fractions may simpiify the evaluation of the nutritive value of grass products, and possibly give a better estimate.

Furthermore, the differences in digestion rates of hay and artificially dried grass suggested that the voluntary intake of artificially dried grass might be higher than of hay.

Table 1. Description and in vitro digestibilities of samples.

Sample No.	Description of sample	In vitro digestibility after hour:					
		6	12	22	30	36	48
1	Hay	–	–	47.9	53.8	57.1	61.9
2	Hay, lst cut after grazing	26.7	37.1	46.2	55.6	63.0	65.2
3	Alfalfa, 2 nd cut	30.4	38.3	46.3	49.0	51.3	52.9
4	Clovergrass hay, lst cut, late	29.7	42.7	52.5	58.3	61.6	65.9
5	Hay, 2 nd cut, without clovergrass	19.4	27.0	34.3	42.7	46.7	52.4
6	Hay, 2 nd cut	27.8	35.8	47.4	54.9	60.6	66.1
7	Hay, lst cut, cowshed manured	29.2	39.9	53.7	61.7	66.1	70.7
8	Meadow hay	30.4	39.3	46.6	57.0	62.5	65.8
9	Hay, lst cut, out 3 wks. too late	–	–	47.2	53.9	55.3	62.9
10	Hay, lst cut, without cowshed manured	–	–	51.2	60.2	62.3	68.7
11	Alfalfa, lst cut	–	–	50.9	53.5	55.5	57.7
12	Pure cocksfoot, 2 nd cut	24.4	33.5	41.9	49.0	55.8	62.7
13	Pure cocksfoot, lst cut	24.8	31.8	40.2	49.3	53.7	59.6
14	Grass, 3 rd cut, harvest date 15.9.	37.2	44.6	52.9	61.1	64.3	68.7
15	Common sample, Alfalfa, 8637	43.7	51.1	56.0	57.3	61.3	59.2
16	Standard sample, of grass, 8636	42.5	50.5	60.4	64.9	67.0	69.1
17	Grass, 2 nd cut, harvest date 27.7.	33.5	42.2	53.3	60.1	65.3	65.6
18	Grass, lst cut, harvest date 5.6.	44.7	53.2	64.6	70.3	79.2	75.8
19	Grass, harvest date 16.8	37.4	46.2	55.6	60.8	63.2	64.8
20	Grass, lst cut, harvest date 1.6.	44.2	53.0	61.8	66.8	75.3	70.7
21	Clovergrass, lst cut, harvest date 23.5.	55.7	62.6	72.1	74.5	77.0	77.4
22	Grass, 2 nd cut, late, harvest date 28.9	45.7	53.8	61.5	63.1	66.4	68.8
23	Clovergrass, harvest date 23.8	41.1	48.6	58.2	63.0	64.8	67.4
24	Grass, 2 nd cut, harvest date 7.7.	35.6	42.6	54.0	60.3	62.5	65.2
25	Grass, lst cut, harvest date 8.6.	48.1	55.5	67.8	72.0	74.7	77.5
26	Italian ryegrass, lst cut, harvest date 10.8.	49.6	60.1	67.9	70.5	72.8	75.2

Table 2. Chemical compositions of amples

Sample	Original					Per cent of
No.	DM	Ash	Org. matter	Crude protein	Crude fibre	NFE + fat
1	94.05	6.36	87.69	12.60	35.38	52.02
2	94.06	5.86	88.20	10.73	35.35	53.96
3	90.27	9.88	80.39	19.86	34.74	45.40
4	92.76	6.20	86.56	11.52	33.50	54.48
5	93.21	5.17	88.04	8.53	36.03	55.44
6	91.70	7.93	83.77	10.95	33.50	55.55
7	94.95	5.10	89.85	8.06	33.31	58.63
8	90.48	5.76	84.72	12.49	27.12	60.39
9	92.45	5.33	87.12	8.82	34.88	56.30
10	95.66	6.28	89.38	9.84	38.02	52.14
11	91.78	9.90	81.88	19.90	35.35	44.75
12	93.21	6.16	87.05	10.31	35.43	54.26
13	92.92	6.33	86.59	13.15	34.10	52.75
14	93.97	6.65	87.32	12.04	29.42	58.54
15	91.17	9.12	82.05	20.00	30.41	49.59
16	91.50	8.87	82.63	16.95	25.72	57.83
17	94.71	6.36	88.35	10.52	33.01	56.47
18	93.20	8.30	84.90	15 85	25.51	58.64
19	93.68	10.76	82.92	18.01	30.99	51.00
20	93.29	11.13	82.16	18.03	26.53	55.44
21	93.11	8.80	84.31	20.50	22.52	56.98
22	93.62	8.41	85.21	18.40	28.28	53.32
23	93.43	7.43	86.00	15.21	29.61	55.28
24	95.06	6.52	88.54	11.61	32.10	56.29
25	93.76	7.43	86.33	15.21	25.45	59.34
26	90.97	10.62	80.35	19.68	23.09	57.23

organic matter

H.C.	NDF	ADF	Lignin	Hem. cell.	Cell.
5.49	66.81	40.8	4.80	26.00	36.01
6.07	67.59	38.39	3.89	29.20	34.50
3.07	47.26	38.37	8.04	8.39	30.83
9.89	63.54	37.64	5.43	25.90	32.21
5.04	67.96	40.69	5.56	27.27	35.13
7.26	62.66	37.80	4.03	24.86	33.77
13.05	63.34	36.95	3.80	26.89	33.15
11.36	55.77	31.71	3.67	24.06	28.94
9.40	62.70	39.10	4.57	23.60	34.53
3.04	60.56	44.94	4.22	15.58	40.27
2.67	54.26	44.35	8.00	9.91	36.35
7.08	66.92	39.69	3.97	27.23	35.72
5.43	64.40	40.08	4.44	24.39	35.57
18.02	55.83	32.70	4.96	23.13	27.74
6.72	44.43	35.80	9.99	8.63	26.81
14.42	50.07	30.99	5.70	19.08	25.29
14.28	60.43	36.88	5.94	23.55	30.94
16.16	53.78	31.97	5.46	21.81	26.51
8.08	57.20	38.52	6.78	18.68	31.74
13.00	53.54	34.64	6.44	18.90	28.20
13.65	50.05	29.11	6.70	20.94	22.41
13.87	53.88	33.00	5.57	20.88	27.43
12.11	56.50	35.87	6.93	20.63	28.94
11.78	62.87	39.33	6.83	23.54	32.50
18.60	52.92	29.74	4.76	23.18	24.98
17.84	46.06	27.31	4.12	17.75	23.19

Table 3. Regressions and correlation coefficients between in vitro digestibility and chemical components.

No.	Descriptian	Total No. of samples	y	x	b	a_o	r	1)
1.	All samples	26	crude protein	in vitro	0.07	9.54	0.11	n.s.
	All samples excl. 3 samples of alfalfa	23	,,	,,	0.32	–8.04	0.51	x
	Hay excl. alfatfa	11	,,	,,	–0.06	14.18	–0.16	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	0.34	–8.13	0.50	n.s.
2.	All samples	26	crude fiber	,,	–0.47	62.38	–0.07	xx
	All samples excl. 3 samples of alfalfa	23	,,	,,	–0.57	69.34	–0.73	xx
	Hay excl. alfalfa	11	,,	,,	–0.09	40.09	–0.17	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.64	72.99	–0.09	xx
3.	All samples	26	NFE + fat	,,	0.40	27.90	0.68	xx
	All samples excl. 3 samples of alfalfa	23	,,	,,	0.15	46.05	0.34	n.s.
	Hay excl. alfalfa	11	,,	,,	0.15	45.73	0.29	n.s.
	Art, dried grass excl. alfalfa	12	,,	,,	0.03	35.15	0.61	x
4.	All samples	26	hydrolysable carbohydrate	,,	0.64	–31.88	0.82	xx
	All samples excl. 3 samples of alfalfa	23	,,	,,	0.64	–31.93	0.77	xx
	Hay excl. alfalfa	11	,,	,,	0.29	–11.33	0.50	n.s.
	Arr. dried grass excl. alfalfa	12	,,	,,	0.55	–23.71	0.08	xx

1) n.s. : not sign.
x : P = 5%
xx : P = 1%

No.	Descriptian	Total No. of samples	y	x	b	a o	r	1)
5.	All samples	26	NDE	,,	–0.29	77.14	–0.27	n.s.
	All samples excl. 3 samples of alfalfa	23	,,	,,	–0.85	115.65	–0.76	xx
	Hay excl. alfalfa	11	,,	,,	–0.36	87.13	–0.52	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.72	105.37	–0.72	xx
6.	All samples	26	ADF	,,	–0.48	67.95	–0.69	xx
	All samples excl. 3 samples of alfalfa	23	,,	,,	–0.55	73.04	–0.71	xx
	Hay excl. alfalfa	11	,,	,,	–0.12	46.88	–0.20	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.69	81.79	–0.86	xx
7.	All samples	26	lignin	,,	–0.08	10.58	–0.34	n.s.
	All samples excl 3 samples of alfalfa	13	,,	,,	0.01	4.34	0.06	n.s.
	Hay excl. alfalfa	11	,,	,,	–0.07	8.98	–0.57	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.10	12.60	–0.50	n.s.
8.	All samples	26	hemioellulose	,,	0.18	9.20	0.21	n.s.
	All samples excl. 3 samples of alfalfa	23	,,	,,	–0.29	42.61	–0.48	x
	Hay, excl. alfalfa	11	,,	.,	–0.24	40.29	–0.34	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.04	23.58	–0.08	n.s.
9.	All samples	26	cellulose	,,	–0.40	57.54	–0.57	xx
	All samples excl. 3 samples of alfalfa	23	,,	,,	–0.56	68.70	–0.68	xx
	Hay excl. alfalfa	11	,,	,,	–0.05	37.90	–0.09	n.s.
	Art. dried grass excl. alfalfa	12	,,	,,	–0.59	69.19	–0.87	xx

1) n.s. : not sign.
x : P = 5%
xx : P = 1%

No. Description	Total No. of samples	y	x	b	a_o	r	1)
10. All samples	26	lignin in %	,,	–0.12	17.85	–0.22	n.s.
All samples excl. 3 samples of alfalfa	23	,,	,,	0.15	–1.35	0.38	n.s.
Hay excl. alfalfa	11	,,	,,	–0.07	11.27	–0.39	n.s.
Art. dried grass excl. alfalfa	12	,,	,,	–0.03	13.16	–0.11	n.s.
11. All samples	26	crude protein + hydrol. carboh.	,,	0.70	21.75	0.65	xx
All samples excl. 3 samples of alfalfa	23	,,	,,	1.00	42.63	0.76	xx
Hay excl. alfalfa	11	,,	,,	0.24	2.85	0.38	n.s.
Art. dried grasss excl. alfalfa	12	,,	,,	0.89	31.85	0.88	xx
12. All samples	26	NFE + fat – hydrol. carboh	,,	–0.23	59.77	–0.46	x
All samples excl. 3 samples of alfalfa	23	,,	,,	–0.43	73.27	–0.70	xx
Hay excl. alfalfa	11	,,	,,	–0.15	57.04	–0.48	n.s.
Art. dried grass excl. alfalfa	12	,,	,,	–0.24	58.84	–0.62	x
13. All samples	26	crude fibre + NFE + fat –hydrol. carboh	,,	–0.71	122.14	–0.65	xx
All samples excl. 3 samples of alfalfa	23	,,	,,	–1.00	142.60	–0.76	xx
Hay excl. alfalfa	11	,,	,,	–o.24	97.12	–0.38	n.s.
Art. dried grass excl. alfalfa	12	,,	,,	0.89	131.79	0.88	xx

1) n..s : not sign.
x : P = 5%
xx : P = 1%

Table 4. Percentage organic matter remaining after various incubation times and the number of hours required for 50% and 75% of the organic matter to be digested.

Sample No.	12 h	24 h	36 h	48 h	50%	75%
1	64	50	43	38	8	20
2	63	50	40	35	9	26
3	62	53	44	47	6	14
4	57	46	38	34	7	19
5	73	63	53	48	11	26
6	64	51	39	34	10	25
7	60	44	34	29	10	20
8	61	49	39	34	8	23
9	66	52	44	37	10	24
10	64	47	38	31	9	24
11	65	48	45	42	8	18
12	66	55	44	38	10	26
13	69	56	46	40	11	25
14	54	44	36	31	6	20
15	49	43	41	41	4	6
16	49	39	33	31	5	14
17	58	46	35	34	6	20
18	47	33	24	24	5	16
19	54	43	37	35	5	15
20	47	36	29	28	5	12
21	37	27	23	23	4	8
22	46	38	34	31	5	10
23	51	41	35	33	5	12
24	57	45	37	35	6	17
25	44	39	25	22	5	15
26	40	31	29	25	5	9

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