



Breed, Sex and Body Condition Score Affect the Meat Quality of Waziri and Mazai Sheep

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ABSTRACT

The present study was performed to investigate the effect of breed, sex and body condition score (designated as weak, medium and healthy with BCS 2, 3 and 4, respectively) on the meat cholesterol, fat, crude protein, ash, moisture and dressing percentage of Waziri and Mazai sheep. A total of 36 mature sheep of Waziri and Mazai were selected and processed for dressing percentage and meat quality through proximate analysis. Waziri sheep had lower cholesterol as compared to Mazai. With the increasing BCS, the cholesterol content was significantly increased in both the breeds. The dressing percentage and crude protein were higher in Waziri but the fat content was found greater in Mazai. Similarly, females have higher average fat content as compared to males. In conclusion, from the health point of view, the mutton of Waziri breed had better nutritional contents compared to Mazai.

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Authors' Contribution

HS and AR conducted the study. RUK and SA edited the paper. SN proofread the paper.

Key words

Cholesterol, Protein, Dressing-percentage, Waziri, Mazai, Mutton.

INTRODUCTION

In many developing countries, sheep production is one of the most important enterprises for the people (Alhidary *et al.*, 2016a, b, c; Abdelrahman *et al.*, 2017a, b; Shakirullah *et al.*, 2017). Meat consumption depends upon the individual's taste, culture, household economy and religion. The farming community of Waziristan mostly rear Waziri sheep for mutton production and Mazai sheep for breeding and milk. According to the Wazir, the mutton of Waziri sheep is very much delicious. The demography of Waziristan supports the sheep husbandry because 70% of the area is hilly and conducive for small ruminant grazing. The people prefer mutton compared to beef. Meat is a balanced nutritional diet due to high availability of essential amino acids, cheap source of minerals, vitamins and some of good quality cholesterol. About 60% of the world population particularly in developing countries are facing shortage of high quality animal proteins. A knowledge based investigation is needed to find the full potential of the local breeds of animals to meet the need of meat (Tufarelli *et al.*, 2012;

Alhidary *et al.*, 2016d; Abudabos *et al.*, 2017a, b).

Public has an increasing distress about cholesterol content in meat or egg (Shahid *et al.*, 2015; Raza *et al.*, 2016; Tehseen *et al.*, 2016). Studies have revealed that the lean mutton has relatively less cholesterol as compared to eggs. Health practitioner advise the public regarding the proper use of polyunsaturated fatty acid and monounsaturated fatty acid in their food to minimize the proportion of bad-cholesterol (Khan *et al.*, 2017). Coronary heart diseases are the major cause of death (Khan *et al.*, 2017).

Little information is available in the published literature about the meat quality of local breeds of small ruminants in Waziristan, Pakistan. The current study was focused to find out the impact of breeds, body condition score (BCS) and sex on the meat quality of Waziri and Mazai.

MATERIALS AND METHODS

Breed selection and characteristics

For the present study, 36 Waziri and Mazai breeds of sheep in equal numbers were selected. Waziri also called Watani in the region while Mazai is called Ahmad Zai. Waziri is native to North Waziristan, whereas Ahmad Zai is inhabit the border areas of two Waziristan.

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Sample collection

A total of 36 Waziri and Mazai meat samples were collected. Sheep breed were categorized before slaughtering on the basis of their health status, breed characteristics and sex. Mutton samples were collected from both male and female of Waziri and Mazai in district Bannu, where inhabitants of Waziristan have migrated along with their livestock to this region due to the military operation “Zerb-e-Azab”. Animals of 3 different body condition score (BCS) were selected for sample collection. Samples were collected from animals having BCS 2 (weak), 3 (medium) and 4 (healthy). Samples (250 g) were collected from thigh region and brought to the PCSIR labs complex for cholesterol determination through Gas Chromatography and for proximate analysis to Animal Nutrition Department Labs The University of Agriculture, Peshawar in ice boxes.

Determination of parameters

The following parameters were determined for the impact of breed, sex and BCS on the physio-chemical properties of Waziri and Mazai sheep mutton of Waziristan.

Dressing percentage

The dressing percentage was determined by the following formula (Warriss, 2000):

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

Chemical analysis

For the chemical analysis, the dry matter (DM) of mutton sample was determined by keeping 10 g sample in laboratory oven at 100°C for overnight (AOAC, 1990). The proximate analysis was performed on the samples taken from fresh mutton. Half of the mutton samples were dried at 60°C for 72 h in hot air oven, while the remaining were frozen in freezer at 0°C for back up use. The air dried samples were minced in Thomas-Willy laboratory mill at 1 mm particle size. The minced samples were stored in clean dry bottles and the bottle was labelled properly. The chemical composition was determined by proximate amylase and cholesterol was carried out through GC-FID.

Cholesterol estimation by gas chromatography (GC-FID)

For the estimation of cholesterol, the mutton samples were collected from the thigh region of sheep. About 2-3 g of frozen sample were taken and completely trimmed from the external fat except the white flecks of marbling with muscles bundles. The trimmed samples were chopped homogenized. The cholesterol contents were estimated by the method described by Shahid *et al.* (2015). Briefly, 2 ml 50% KOH and 8 ml 95% ethanol were mixed with

the sample and then heated for 30 min at 80°C in a water bath. The samples were cooled at room temperature and then added 3 ml toluene and 3 ml distil water. The upper toluene layer which contained cholesterol were collected and washed with 2 ml KOH 0.5M. The final toluene layer was poured into a 50 ml test tube containing about 5–7g of anhydrous sodium sulfate. The 3 ml of crystal-clear toluene solution containing extracted cholesterol content were separated. From the sample, 1µl was run through the GC-FID. Total run time was 26.05 min, initial temperature was 200°C, which was gradually increased to 280°C.

Protein, fat, moisture and ash

Samples were analyzed for nitrogen (Kjeldahl method; AOAC, 1990), fat (AOAC, 2000), moisture (AOAC, 2005) and ash (AOAC, 2000).

Statistical analysis

The data were recorded in the Microsoft excel sheet. For statistical analysis, ANOVA was performed through three factorial complete randomized designs (CRD). Whereas breed, sex and body condition of the animals were considered as independent variable and parameters such as cholesterol content, protein content, fat content, moisture, ash and dressing percentage were considered as dependent variables. The comparison between the group means was tested through LSD test.

RESULTS AND DISCUSSION

The effect of breed, sex and BCS on the meat concentration of cholesterol, crude protein, fat, moisture and ash contents of the two breeds is given in Table I. The results show that the difference between the two breeds of sheep was statistically significant ($P < 0.001$). The highest cholesterol level was found in healthy animals followed by medium and the weak animals. As the BCS of the animals is increasing, the average cholesterol content of mutton also increasing. Data show that numerically the female have more cholesterol content in their meat as compared to male. On average, females animals have 1 % more cholesterol content than males but statistically no difference was found. The interaction between breed and BCS in the present study was highly significant ($P < 0.01$). The findings were in line with Arsenos *et al.* (2000) who reported that the mean cholesterol content of different sheep breed have significant effect. Arsenos *et al.* (2000) reported that the female sheep have more cholesterol content as compared to male. The results in the present study however, were not significant. The reason could be the difference between the breeds and other experimental conditions.

Table I.- Effect of breed sex and BCS on cholesterol, crude protein, fat, moisture and ash contents in mutton of Waziri and Mazai breeds of sheep.

Breed	Weak (BCS 2)		Medium (BCS 3)		Healthy (BCS 4)		P Value
	Male	Female	Male	Female	Male	Female	
Cholesterol (%)							
Mazai	14.05±0.56	16.61±1.41	18.03± 4.62	20.21±0.44	35.04±1.70	34.05±1.50	<0.001
Waziri	8.81 ± 0.43	8.88±0.42	12.36 ± 1.44	16.36±0.32	15.60±0.45	17.66±0.32	NS
Breed <0.001, Breed × BCS <0.001							
Crude protein (%)							
Mazai	26.15±0.05	24.38±0.28	26.69±0.62	24.75±0.16	26.70±0.11	24.73±0.05	<0.001
Waziri	28.73±0.04	26.31±0.12	26.19±0.15	26.25±0.00	28.48±0.09	26.11±0.00	<0.001
Breed <0.001, Breed × BCS >0.05							
Fat (%)							
Mazai	19.29±0.32	21.61±0.35	21.96±0.01	23.33±0.32	22.95±0.01	25.31±0.333	<0.001
Waziri	16.64±0.32	19.63±0.32	19.31±0.33	21.50±0.27	20.33±0.3	23.17±0.202	<0.001
BCS <0.001							
Moisture (%)							
Mazai	75.17±0.51	72.45±0.21	74.02±0.51	71.75±0.21	71.86±0.81	70.97±0.41	NS
Waziri	75.61±0.22	72.59±0.21	73.38±0.22	72.29±0.32	71.07±0.12	70.40±0.32	<0.001
BCS <0.01							
Ash (%)							
Mazai	1.49±0.07	1.54±0.05	1.73±0.12	1.79±0.06	1.81±0.09	1.80±0.09	NS
Waziri	1.49±0.04	1.50±0.16	1.76±0.04	1.76±0.06	1.84±0.02	1.84±0.02	NS
BCS<0.001							

The impact of the breed on the percent crude protein of the two sheep breeds was significant ($P<0.01$). No difference was found among the BCS and crude protein content and the effect was found non-significant ($P\geq 0.05$). The impact of sex on crude protein content of the mutton samples among the two sheep breed was significant ($P<0.05$). Data show that the males have usually greater crude protein content in their lean meat as compared to females. On average, male animals have 2% greater protein content than females. Present research findings were in line with [Jandasek et al. \(2014\)](#) who reported that protein content of different sheep breeds have significant ($P<0.05$) effect. In the present research, Waziri breed has more percent protein content followed by Mazai. This result was supported by [Costa et al. \(2009\)](#). The effect of sex on mutton crude protein was explained as non-significant by [Johnson et al. \(2014\)](#). Since the male are more active than female therefore, their muscle contents are higher and cholesterol contents are less.

The overall mean percent fat content for Mazai was higher than Waziri breed. The highest fat content in

Mazai female was found in healthy group, followed by medium group and least fat content was found in the weak group. The result also showed that the mean percent fat content was low in weak animals as compared to medium and healthy sheep. Similarly, the effect of BCS on the percent fat content for Waziri female weak group had lower concentration as compared to medium and healthy groups. The fat content between the two breeds of sheep was statistically found significant ($P<0.05$). The mutton fat content and BCS of the sheep were directly dependent on each other when BCS was increasing the fat content was also increasing. These conclusions were significantly ($P<0.05$) affected by the BCS. The impact of sex on fat content of the mutton samples of the two breeds was significant ($P<0.05$). Data shows that the male had less % fat in their lean meat as compared to female sheep mutton. Present research findings were similar with [Camacho et al. \(2013\)](#). The difference is due to the morphological characteristics of both the breeds. The Mazai sheep have huge fatty tail and lives in cold region of Waziristan. The reason could be the genetics of the breeds. The impact

of BCS on percent fat content of the present study was supported by *Atti et al. (2000)* and *Camacho et al. (2013)*. They stated that female sheep carcass have more fat content as compared to male.

The mean percent moisture content for Mazai male of weak group was followed by medium and healthy group. In Mazai female, the mean moisture percent was highest for the weak group, followed by medium group and the least for the healthy group. There is inverse relationship between BCS and moisture content because when BCS increases the moisture content decreases. Weak animals have the highest overall moisture content followed by medium group and the least for health group. The sex affected the moisture content of the mutton samples of the two sheep breeds which were significant ($P < 0.05$). Data showed that the males have greater moisture content in their lean meat as compared to females. On average, males animals have approximately 2% greater moisture content than females.

The findings of the present study was supported by the results of *Johnson et al. (2014)*, who showed that the male has higher moisture content than the female. The result of the present study was similar to *Zhang et al. (2010)* who mentioned that sex can affect the water content significantly. *Stankov et al. (2002)* also stated that the moisture content and fat level in sheep meat was directly related to BCS of the animal because when BCS increasing the fat level also increases but water level decreases.

Numerical difference was observed in ash content between both breeds of sheep but statistically not different. The ash content and BCS of the sheep were directly proportion to each other. When BCS increased, the ash content was also increased. These conclusion were significantly ($P < 0.05$) affected by the BCS as the weak group (both breed, males and females) have shown less ash content as compared to medium group and healthy. This might be due to the deposition of calcium in the bones. Data show that numerically the female have more ash content in their lean meat as compared to male. On average, female animals have 1% more ash content than male but the different was non- significant. The results of current study were similar to *Jandasek et al. (2014)*. The authors also revealed that there were no significant differences in ash content of different sheep breed. This result was also supported by *Hoffman et al. (2003)* and *Costa et al. (2009)* who stated that breed has no significant effect on the ash content of mutton. Sex has no significant effect on percent ash content of mutton of Waziri and Mazai sheep breed which was supported by the findings of *Santos et al. (2007)*.

The result of the study showed that dressing percentage of the two breeds was significant ($P < 0.01$) ash

shown in *Table II*. The Waziri breed had greater dressing percentage than the Mazai breed. Present findings were supported by *Rahman et al. (2013)* who stated that the *Turki* sheep breed have greater dressing percentage than Afghani and Bulchai breeds. In the present study, findings of Waziri sheep breed have greater dressing percentage as compared to the Mazai breed because the Mazai have more fat content and lesser bones and muscles tissue. In the present study, sex has also a significant ($P < 0.01$) effect on the dressing percentage of the sheep breed. Similar results were reported by *Lobley et al. (1990)*. Their results revealed that the male displayed greater nitrogen retention index than female and therefore developed proportionally more muscles and adipose tissue.

Table II.- The effect of sex on the dressing percentage of Waziri and Mazai sheep.

Breed	Male	Female	P value
Mazai	56.71± 0.39	53.34± 0.65	<0.001
Waziri	59.34± 0.82	58.36± 0.56	<0.001

CONCLUSION

The results of the present study revealed that Waziri breed has less cholesterol and fat contents than Mazai but higher dressing percentage and protein contents.

Statement of conflict of interest

The authors declare no conflict of interest.

REFERENCES

- Abdelrahman, M.M., Aljumaah, R.S. and Khan, R.U., 2017a. Effects of prepartum sustained-release trace elements ruminal bolus on performance, colostrum composition and blood metabolites in Najdi ewes. *Environ. Sci. Pollut. Res.*, **24**: 9675-9680. <https://doi.org/10.1007/s11356-017-8625-1>
- Abdelrahman, M.M., Alhidary, I., Alyemni, A.H., Khan, R.U., Bello, A.R.S., Al-Saiady, M.Y. and Amran, R.A., 2017b. Effect of alfalfa hay on rumen fermentation patterns and serum biochemical profile of growing Naemi lambs with ad libitum access to total mixed rations. *Pakistan J. Zool.*, **49**: 1519-1522. <https://doi.org/10.17582/journal.pjz/2017.49.4.sc6>
- Abudabos, A.M., Alyemni, A.H., Dafalla, Y.M. and Khan, R.U., 2017a. The effect of phytogenics on growth traits, blood biochemical and intestinal histology in broiler chickens exposed to *Clostridium perfringens* challenge. *J. appl. Anim. Res.*, **46**: 691-

695. <https://doi.org/10.1080/09712119.2017.1383258>
- Abudabos, A.M., Alyemni, A.H., Dafalla, Y.M. and Khan, R.U., 2017b. Effect of organic acid blend and *Bacillus subtilis* alone or in combination on growth traits, blood biochemical and antioxidant status in broiler exposed to *Salmonella typhimurium* challenge during the starter phase. *J. appl. Anim. Res.*, **45**: 538-542. <https://doi.org/10.1080/09712119.2016.1219665>
- Alhidary, I.A., Abdelrahman, M.M., Alyemni, A.H., Khan, R.U., Al-Saiady, M.Y., Amran, R.A. and Alshamiry, F.A., 2016a. Effect of alfalfa hay on growth performance, carcass characteristics, and meat quality of growing lambs with ad libitum access to total mixed rations. *Rev. Bras. Zootec.*, **45**: 302-308. <https://doi.org/10.1590/S1806-92902016000600004>
- Alhidary, I., Abdelrahman, M.M., Alyemni, A.H., Khan, R.U., Al-Mubarak, A.H. and Albaadani, H.H., 2016b. Characteristics of rumen in Naemi lamb: Morphological characteristics in response to altered feeding regimen. *Acta Histochem.*, **118**: 331-337. <https://doi.org/10.1016/j.acthis.2016.03.002>
- Alhidary, I.A., Abdelrahman, M.M. and Khan, R.U., 2016c. Comparative effects of direct-fed microbial alone or with a traces mineral supplement on the productive performance, blood metabolites and antioxidant status of grazing Awassi lambs. *Environ. Sci. Pollut. Res.*, **23**: 25218-25223. <https://doi.org/10.1007/s11356-016-7684-z>
- Alhidary, I.A., Abdelrahman, M.M., Khan, R.U. and Haroon, R.M., 2016d. Antioxidant status and immune responses of growing camels supplemented a long-acting multi-trace minerals rumen bolus. *Italian J. Anim. Sci.*, **15**: 343-349. <https://doi.org/10.1080/1828051X.2016.1186502>
- AOAC, 1990. *Official methods of analysis*. 15th ed., Association of Official Analytical Chemists, Washington, DC.
- AOAC, 2000. *Official methods of analysis*. 17th ed., Official Method 920.39. International Gaithersburg, MD.
- AOAC, 2005. *Official methods of analysis*. 16th ed., Association of Official Analytical Chemists Washington, DC.
- Arsenos, G., Zygyojannis, D., Kufdis, D., Katsaounis, N. and Stamataris, C., 2000. The effect of breed slaughter weight and nutritional management. *Small Rumin. Res.*, **36**: 275-283. [https://doi.org/10.1016/S0921-4488\(99\)00107-8](https://doi.org/10.1016/S0921-4488(99)00107-8)
- Atti, N., Bocquier, F., Theriez, M., khaldi, G. and Kayouli, C., 2009. Physical and chemical characterization of lamb meat from different genotypes submitted to diet with different fibre contents. *Small Rumin. Res.*, **81**: 29-34. <https://doi.org/10.1016/j.smallrumres.2008.10.007>
- Beserra.F.J., Madruga, M.S., Leite, A.M., Silva, E.M.C. and Maia, E.L., 2004. Effect of age at slaughter on chemical composition of meat from Moxotó goats and their crosses. *Small Rumin. Res.*, **55**: 177-181. <https://doi.org/10.1016/j.smallrumres.2004.02.002>
- Camacho, A., Capote, J., Mata, J., Arguello, A., Viera, J.J. and Bermejo, L.A., 2013. Effect of breed (wool and hair) and sex on the carcass quality of suckling lambs under intensive management. *Rev. Bras. Zootec.*, **42**: 892-898. <https://doi.org/10.1590/S1516-35982013001200009>
- Costa, R.G., Bastista, A.S.M., Madruga, M.S., Neto, S.G., Queiroga, R.C.R.E., Filho, J.T.A. and Villarroel, A.S., 2009. Physical and chemical characterization of lamb meat from different genotypes submitted to diet with different fibre contents. *Small Rumin. Res.*, **81**: 29-34. <https://doi.org/10.1016/j.smallrumres.2008.10.007>
- Floch, J., Lees, M. and Stanly, G.H.S., 1957. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biochem.*, **22**: 497-509.
- Gaias, G., 2012. *Body condition score and body composition of Sarda dairy ewes*. M. Sc. thesis, Scuola di Dottorato di Ricerca Scienze dei Sistemi Agrari e Forestali e delle Produzioni Alimentari. Indirizzo Scienze e Tecnologie Zootecniche Ciclo XXIV.
- Hoffman, L.C., Muller, M., Cloete, S.W.P. and Schmidt, D., 2003. Comparison of six crossbred lamb types: Sensory, physical and nutritional meat quality characteristics. *Meat Sci.*, **65**: 1265-1274. [https://doi.org/10.1016/S0309-1740\(03\)00034-2](https://doi.org/10.1016/S0309-1740(03)00034-2)
- Jandasek, J., Milerski, M. and Lichovnikova, M., 2014. Effect of sire breed on physico-chemical and sensory characteristics of lamb meat. *Meat Sci.*, **96**: 88-93. <https://doi.org/10.1016/j.meatsci.2013.06.011>
- Johnson, D.D., Eastridge, J.S., Neubauer, D.R. and McGowan, C.H., 2014. Effect of sex class on nutrient content of meat from young goat. *J. Anim. Sci.*, **73**: 296-301. <https://doi.org/10.2527/1995.731296x>
- Khan, R.N. and Usmani, R.H., 2005. Characteristics of rural subsistence small holder livestock production system in mountainous areas of KPK, Pakistan. *Pak. Vet. J.*, **25**: 344-352.
- Khan, R.U., Naz, S. and Abudabos, A.M., 2017. Towards a better understanding of the therapeutic

- applications and corresponding mechanisms of action of honey. *Environ. Sci. Pollut. Res.*, **24**: 27755-27766. <https://doi.org/10.1007/s11356-017-0567-0>
- Lobley, G.E., Connel, A., Milne, E., Buchan, V., Calder, A.G., Anderson, S.E. and Vint, H., 1990. Muscle protein synthesis in response to testosterone administration in wither lambs. *Br. J. Nutr.*, **64**: 691-704. <https://doi.org/10.1079/BJN19900071>
- Rahman, A., Rahman, S., Akhtar, S., Jan, I., Qurshri, M.S. and Rahman, S.U., 2013. Determination of meat yield and dressing percentage of Turki, Afghan, Arabi and Baluchi sheep breeds in Afghanistan. *Sarhad J. Agric.*, **29**: 113-117.
- Raza, T., Chand, N., Khan, R.U., Shahid, M.S. and Abudabos, A.M., 2016. Improving the fatty acid profile in egg yolk through the use of hempseed (*Cannabis sativa*), ginger (*Zingiber officinale*), and turmeric (*Curcuma longa*) in the diet of Hy-Line White Leghorns. *Arch. Anim. Breed.*, **68**: 183-190. <https://doi.org/10.5194/aab-59-183-2016>
- Santos, V.A.C., Silva, S.R., Mena, E.G. and Azevedo, J.M.T., 2007. Live weight and sex effects on carcass and meat quality of “Borrego terrincho–PDO” suckling lambs. *Meat Sci.*, **77**: 654-661. <https://doi.org/10.1016/j.meatsci.2007.05.019>
- Shakirullah, Qureshi, M.S., Akhtar, S. and Khan, R.U., 2017. The effect of vitamin E and selenium on physiological, hormonal and antioxidant status of Damani and Balkhi sheep submitted to heat stress. *Appl. Biol. Chem.*, **60**: 585-590. <https://doi.org/10.1007/s13765-017-0313-9>
- Shahid, S., Chand, N., Khan, R.U., Suhail, S.M. and Khan, N.A., 2015. Alterations in cholesterol and fatty acids composition in egg yolk of Rhode Island Red x Fyoumi Hens Fed with Hemp Seeds (*Cannabis sativa* L.). *J. Chem.*, Article ID 362936.
- Stankov, I.K., Todorov, N.A., Mitev, J.E. and Miteva, T.M., 2002. Study on Some qualitative features of meat from young goat of Bulgarian breeds and crossbreeds of goats slaughtered at various ages. *Asian-Aust. J. Anim. Sci.*, **15**: 283-289.
- Tehseen, M., Tahir, M., Khan, R.U., Jabbar, A., Ahmad, B., Ahsan, T., Khan, S. and Abudabos, A.M., 2016. Additive effect of *Nigella sativa* and *Zingiber officinale* herbal mixture on performance and cholesterol profile in broiler. *Philip. Agric. Sci.*, **99**: 408-413.
- Tufarelli, V., Khan, R.U., Mazzei, D. and Laudadio, V., 2012. Performance and carcass measurements of ewe lambs reared in a feedlot and fed wheat (*Triticum durum* Desf.) middling total mixed rations in the summer season. *Trop. Anim. Hlth. Prod.*, **44**: 779-784. <https://doi.org/10.1007/s11250-011-9967-1>
- Warriss, P.D., 2000. *Meat science*, 1st ed. ISBN: 0 85199 424 5. CABI Publish. New York, USA.
- Zhang, Y.Y., Zan, L.S., Wang, H. B., Xin, Y. P., Adoligbe, C.M. and Ujan, J.A., 2010. Effect of sex on meat quality characteristics of Qinchuan cattle. *Afr. J. Biotechnol.*, **9**: 4504-4509.