Effect of information on geographical origin, duration of transport and welfare condition on consumer’s acceptance of lamb meat

Mariangela Caroprese1✉, Maria Giovanna Ciliberti1, Rosaria Marino1, Fabio Napolitano2, Ada Braghieri2, Agostino Sevi1 & Marzia Albenzio1

Animal production system and welfare conditions can influence consumers’ acceptance, as meat from animals grazing in natural pasture and labelled with information about high standards of welfare is preferred. In addition, geographical origin of food is recently considered one of the main information influencing the consumers’ acceptance. Local products are collectively associated with high quality attributes by the consumers related to shorter transport and good welfare. Lamb meat is considered local and typical food; however, it is common to find in the same market both local and imported lamb meat. The present investigation aimed at understanding the importance of information about geographical origin, transport duration, and welfare condition of lambs for consumers and their actual liking. Moreover, the quality of lamb meat from local and imported animals as affected by short or long transport was assessed. Data demonstrated that both short and long transport did not affect organoleptic quality of meat; this result was corroborated by an absence of both metabolic and immune stressors in long term transport lambs except for haptoglobin, cortisol and glucose. However, the expected and actual acceptability were affected by the information with higher scores for local lamb when information on the geographical origin, transport duration, and welfare condition was provided to the consumers.

Consumers’ quality perception evolves continuously according to different phenomena and cultural scenario. The geographical origin is considered a relevant credence attribute due to the consumers’ ethnocentrism inducing a preference for food originating from the consumers’ own provenance1; thus, the perception of food quality is reinforced when the specific producing areas are limited. Investigations on information about origin of food and consumers’ responses demonstrated that the origin/region of production is one of the most important informational cues for the consumer2. In particular, a Spanish case study discovered that the quality labels such as Protected Geographical Indications (PGI) is an important factor for purchasing of lamb meat3. It has been found that the stronger and more favourable the association of the food with the country, the greater is the level of food success to consumers4. In this context, Jordana5 has shown that traditional food has good perspectives for growing in the future if appropriate communication, legal protection of collective brands, quality assurance and innovation will be achieved as challenges. For the quality assurance, information about healthiness is considered as one of the main quality attributes influencing the expectance and the overall acceptance of food that encourage the consumers to try them6.

In Guerrero et al. study7 it has been found that consumers consider four important specific dimensions of traditional food products, including familiarity of the product, processing through traditional recipes, sensory properties and the origin of the product. Lamb meat has a familiarity dimension and its sensory properties are specific and linked to the habit of consumers’ actual area8. Moreover, for lamb meat, quality attributes are connected to

1Department of Agricultural, Food, and Environmental Sciences, University of Foggia, Via Napoli, 25-71121, Foggia, Italy. 2School of Agriculture, Forest, Food and Environmental Sciences, Università degli Studi della Basilicata, Via dell’Ateneo Lucano 10, 85100, Potenza, Italy. ※e-mail: mariangela.caroprese@unifg.it
animal grazing in natural pasture, and consumers are attracted by labelling information about welfare and feeding systems. Production of lamb meat is relatively international, as a consequence, meat from different countries can be found in the same market, but consumers are often advised of lamb meat origin. The transport of animals from farm to abattoir causes an inevitable condition of stress in animals according to Broom's definitions of stress as the state of an individual as regards its attempts to cope with its environment, and as an effect of the environment on an individual that overcomes the animal's control system and reduces its fitness. Exposition to transport stressors involving temperature fluctuations, handling, and mixing with conspecifics, results in an alteration of animals' homeostasis which is counterbalanced by an increase of the activity of a number of enzymes and hormones. Road transport related-stress could negatively affect the animal performance, being responsible for increased mortality and decreased meat quality and animal welfare with potentially relevant economic losses.

Our hypothesis was that the information about local lamb production, subjected to short transport and good welfare can influence the overall consumers' acceptability respect with imported lamb meat, subjected to long transport and poor welfare, reinforcing the lamb meat local market as more ethical and animal welfare friendly. In order to mimic a more real-life consuming experience and for marketing purposes it is interesting to evaluate the impact of non-sensory attributes (i.e. information) on consumer liking. Therefore, the aim of the present study was twofold: i) to assess the welfare conditions and quality of meat from local lambs subjected to a short transport before slaughter (STR), and lambs imported subjected to a long transport time before slaughter (LTR), ii) to investigate the effect of the information about lamb geographical origin, transport duration, and welfare condition on consumers' perceived, expected and actual acceptability.

Results and Discussion

Preliminary focus group and food purchase decision. In order to evaluate the interest of consumers regarding the consumption of lamb meat from different geographical origins and with different welfare conditions, a preliminary focus group was carried out. The discussion within the focus groups recognised lamb meat as a product generally consumed in particular occasions (e.g. Christmas, Easter) and events (e.g. dinner with the enlarged family, dinner with friends). The aspects considered relevant in the purchase decision of the people composing the focus groups were classified according to the topics identified during the discussion (Table 1). Three main clusters were identified. The first one concerned the sensory characteristics of lamb meat; in particular, flavour and taste were considered to be highly intense, thus on one hand capable of differentiate the product, on the other potentially inhibiting lamb meat consumption. The age of the lambs at slaughter was also mentioned as a factor indirectly affecting purchase decision as it was deemed capable of influence the sensory characteristics of the product. Another intrinsic characteristic identified by the focus groups as relevant was the healthiness of the product. The second cluster included the geographical origin and the brand of the product. The former may influence purchase decision for safety reasons as the discussion highlighted a higher trust in the national sanitary control processes and transparency as compared with imported lambs. In addition, the focus groups emphasised that imported lambs may undergo long transport, which induces high stress levels, thus potentially compromising the quality of the product. The brand may add on this by enabling the recognition of local products, obtained from animals subjected to very short distance transport, thus deemed safer and higher quality. The focus groups also identified ethical concerns related to the farming systems used to raise the animals and potentially affecting purchase intentions. Free-ranging and ewe-reared animals were perceived as being in higher welfare conditions, in terms of expression of natural behaviour. In addition, a high welfare state of the animals was also considered to be able to positively affect product quality.

The scores given by 101 consumers to the items identified by the focus groups are reported in Table 2. The item geographical origin received the highest score albeit not significantly different from taste. Previous studies showed that safety and sensory characteristics were the main choice determinants for various food products; whereas, the origin was less important and related to the traditional image of locally transformed animal-based products. These results are only apparently in contrast with our findings. Such differences can be explained by taking into account the reasons given by the focus groups for indicating the geographical origin as a food choice determinant: trust in the national control process, and negative effects of long transport on meat quality, both related to the overall safety of lamb. In our study the lack of any references to typical and traditional
transformation practices was likely due to the fact that lamb is sold as fresh product with little or no process characteristics possibly linked to its image.

As also observed for other animal products, ethical concerns played an important role in defining consumer purchase decision, although less than sensory and safety characteristics. In particular, Napolitano et al. noted that the information concerning animal welfare is able to increase the expectations of the consumers about various animal-based products. In addition, the consumers generally tend to assimilate their liking and increase the actual acceptability towards the expectations. However, both sensory characteristics and ethical concerns contribute to the expression of consumer preferences.

As to brand, previous reports indicate that this item tends to show a low rank in affecting consumers purchase decision. This is confirmed for lamb which is commonly sold as an undifferentiated product. Dietetic characteristics were the least scored item. This result can be attributed to the fact that lamb is not part of the regular diet of most Italian consumers, whereas it is predominantly purchased and consumed in particular events and occasions, as also stated in the discussion of the focus groups. Therefore, consumers are possibly aware that this food may have a minor impact on their health status. Results from the focus group were the preliminary to design the experiment on transported lambs and to plan the subsequent consumer test to investigate the effect of the information about lamb geographical origin, transport duration, and welfare condition on consumers’ acceptability.

### Effects of Transport on Blood Parameters

Transport stress is activated by the complex series of operations related to transport and slaughter, and can be measured with both behavioural and physiological indicators. Plasma cortisol and glucose levels have been considered as reliable biomarkers to measure stress responses of farm animals. Lambs subjected to long transport resulted in an increase of both haptoglobin and cortisol levels, with a reduction of glucose level \( P = 0.007, 0.015, \text{and} < 0.0001, \text{respectively, Table 3} \). Individuals exposed to a relatively short-term or long-term stressor can react changing the levels of hormones that modify the availability of substrates, being more readily for subsequent actions. According to Sapolsky et al., the first wave of endocrine response occurs within seconds, and involves secretion of catecholamines, hypothalamic release of CRH and, perhaps 10 sec later, enhanced secretion of pituitary ACTH, pituitary secretion of PRL and (in primates), GH, and pancreatic secretion of glucagon, together with decreased release of GnRH and of pituitary gonadotropins. A second, wave involves the steroid hormones; therefore, in some minutes, GC secretion is stimulated and gonadal steroid secretion declines. Moreover, suboptimal condition of transport, causes also an increase in the blood plasma, of acute phase proteins among which, haptoglobin, serum amyloid A and C-reactive protein. The role of these acute phase proteins regards the defences to diseases and the modulation of inflammatory responses.

| Item                              | Score*       |
|-----------------------------------|--------------|
| Geographical origin               | 6.60 ± 0.17a |
| Taste                             | 6.29 ± 0.17b |
| Rearing system (i.e. confinement or free-ranging) | 6.00 ± 0.17c |
| Suckling system (i.e. ewe reared or artificially reared) | 5.54 ± 0.17d |
| Brand                             | 5.24 ± 0.17d |
| Dietetic characteristics          | 4.52 ± 0.17e |

Table 2. Scores given to each item included in the Food Choice Questionnaire and affecting lamb purchase decision (means ± SE). *Mean scores obtained using a 7-point Likert scale (1 = unimportant to 7 = very important). Different letters indicate significant differences at \( P < 0.05 \).

| Item      | STR | LTR | SEM | P-value |
|-----------|-----|-----|-----|---------|
| Haptoglobin, mg/mL | 1.00 | 2.86 | 0.45 | 0.007   |
| Cortisol, ng/mL   | 12.94 | 21.70 | 2.40 | 0.015   |
| Glucose, mg/dL    | 87.12 | 64.47 | 3.34 | < 0.000 |
| NEFA, μmol/L      | 347.40 | 318.13 | 42.19 | 0.620   |
| CK, U/L            | 605.47 | 510.87 | 188.86 | 0.730   |
| Neutrophils, %    | 39.26 | 47.38 | 4.4  | 0.240   |
| Lymphocytes, %    | 54.56 | 42.65 | 5.56 | 0.120   |
| Monocytes, %      | 4.88  | 6.48  | 1.3  | 0.430   |
| Eosinophils, %    | 0.37  | 0.41  | 0.07 | 0.730   |
| Basophils, %      | 0.99  | 1.18  | 0.09 | 0.160   |
| N/L                | 0.81  | 1.18  | 0.2  | 0.230   |
| Haematocrit, %    | 24.85 | 23.2  | 1.9  | 0.560   |
| PCV, %             | 33.53 | 32.62 | 0.5  | 0.220   |

Table 3. Effects of pre-slaughter short (STR) or long transport (LTR) on lamb blood parameters (Least Squares means ± SEM). NEFA: non-esterified fatty acid; CK: creatinine kinase; N/L: Neutrophil to lymphocyte ratio; PCV: packed cell volume.

As to brand, previous reports indicate that this item tends to show a low rank in affecting consumers purchase decision. This is confirmed for lamb which is commonly sold as an undifferentiated product. Dietetic characteristics were the least scored item. This result can be attributed to the fact that lamb is not part of the regular diet of most Italian consumers, whereas it is predominantly purchased and consumed in particular events and occasions, as also stated in the discussion of the focus groups. Therefore, consumers are possibly aware that this food may have a minor impact on their health status. Results from the focus group were the preliminary to design the experiment on transported lambs and to plan the subsequent consumer test to investigate the effect of the information about lamb geographical origin, transport duration, and welfare condition on consumers’ acceptability.

**Effects of Transport on Blood Parameters.** Transport stress is activated by the complex series of operations related to transport and slaughter, and can be measured with both behavioural and physiological indicators. Plasma cortisol and glucose levels have been considered as reliable biomarkers to measure stress responses of farm animals. Lambs subjected to long transport resulted in an increase of both haptoglobin and cortisol levels, with a reduction of glucose level \( P = 0.007, 0.015, \text{and} < 0.0001, \text{respectively, Table 3} \). Individuals exposed to a relatively short-term or long-term stressor can react changing the levels of hormones that modify the availability of substrates, being more readily for subsequent actions. According to Sapolsky et al., the first wave of endocrine response occurs within seconds, and involves secretion of catecholamines, hypothalamic release of CRH and, perhaps 10 sec later, enhanced secretion of pituitary ACTH, pituitary secretion of PRL and (in primates), GH, and pancreatic secretion of glucagon, together with decreased release of GnRH and of pituitary gonadotropins. A second, wave involves the steroid hormones; therefore, in some minutes, GC secretion is stimulated and gonadal steroid secretion declines. Moreover, suboptimal condition of transport, causes also an increase in the blood plasma, of acute phase proteins among which, haptoglobin, serum amyloid A and C-reactive protein. The role of these acute phase proteins regards the defences to diseases and the modulation of inflammatory responses.
such as haptoglobin, which removes damaged haemoglobin and has immunomodulatory role during inflammation. Our data showed both increasing of haptoglobin and cortisol in LTR and agreed with Ekiz et al. who found significantly increased cortisol levels after 75 min transport in lambs in comparison to initial levels. On the contrary, Dalmau et al. stated that no effect on serum cortisol was found in lambs transported for 24 h, even if higher faecal cortisol metabolites were found as compared with lambs transported for 1 h. Thus, the hypothesis of accumulative stress in lambs transported for long period was suggested. The secretion of cortisol activates gluconeogenesis by stimulating the liver to produce more glucose to sustain stressful situations starting from fat and proteins. Adenkola and Ayo found that plasma glucose level tended to increase during transport as a stress response, primarily due to gluconeogenic effect of cortisol. In goats, Kannan et al. reported that glucose concentration began decreasing at 3 h after 2.5 h transportation. In our study LTR resulted in a lower glucose level than STR, probably associated with the higher consumption of glucose as fuel for restoring homeostasis.

In our study the level of both NEFA and CK, and the white blood cell percentages were not affected by the duration of lamb transport. CK and lactate dehydrogenase (LDH) activity are considered as indicators of muscle damage, high physical activity or trauma occurring during transport. Moreover, NEFA concentration increased concomitantly during long transport in response to adrenaline release and is considered a good indicator of body fat utilization in stressful condition during transport. The lack of differences between STR and LTR in CK and NEFA levels suggested that lambs recruited in the trial showed minimal muscle trauma and positively activated the metabolic response to transport stress. This result agreed with those obtained from De la Fuente et al. in which no differences in CK between lambs subjected to different transport times were registered. Moreover, the welfare issues assessed at slaughterhouse (Table 4), taking into account the percentage of active animals, ambulatory animals, injuries and lameness, did not evidence differences between STR and LTR lambs, corroborating the lack of strong negative effect of transport condition on lambs.

**A stressful condition can be detected also by the evaluation of the changing of white blood cell (WBC) numbers, packed cell volume (PCV)/haematocrit, and the N/L ratio.** In our study no changes in white blood cells (neutrophils, lymphocytes, monocytes, eosinophils, basophils, and N/L ratio), haematocrit, and PCV between STR and LTR were registered. In condition of stress, the increase of cortisol was associated to neutrophilia, lymphopenia and declined in PCV, thus consequently increasing the probability of health problems and reducing the ability of the lambs to cope with transport stress. The changes in PCV could be related to dehydration; however, animals overheated and dehydrated did not registered different PVC than animals at normal temperature and degree of hydration. In certain circumstances PCV can be a useful measure but is not a general welfare measure. In our experiment, transport duration did not affect the haematocrit and N/L ratio, which were within physiological reference values for lambs of a similar age and weight, as reported in previous papers. On the whole, physiological response of lambs to duration of transport, was characterized by cortisol, haptoglobin and glucose levels alteration without affecting CK, NEFA and other haematric parameters; thus, demonstrated a lack of any additional stress to the transport.

**Meat quality.** No significant differences due to transport duration on lamb meat chemical composition were found (data not shown). Protein content and fat content ranged from 20.03 to 20.48 ± 0.14 (STR and LTR), and from 3.28 to 3.45 ± 0.11 (LTR and STR), respectively.

|                         | STR       | LTR       | P-value |
|-------------------------|-----------|-----------|---------|
| Active animals, %       | 80 ± 9.09 | 86.7 ± 10.6| 0.580   |
| Ambulatory animals, %   | 13.3 ± 9.09| 20 ± 10.6 | 0.580   |
| Injuries, %             | 0         | 6.6 ± 6.6 | 0.330   |
| Lameness, %             | 0         | 6.6 ± 6.6 | 0.330   |
| Dead, %                 | 0         | 0         | 0.990   |

Table 4. Welfare issues (percentage of active animals, ambulatory animals, injuries, lameness, dead ±SEM) of lambs subjected to short pre-slaughter (STR) or long pre-slaughter transport (LTR).
indicators showing no marked differences between lambs subjected to long or short transport, thus, suggesting that pre-slaughter stressors did not lead to a decline in meat quality.

Consumers’ acceptability test. Table 6 shows the results of perceived, expected and informed acceptability of meat from local lambs subjected to a short transport time before slaughtering with a low impact on animal welfare and from imported lambs subjected to a long transport time before slaughtering with an important impact on animal welfare. No difference between STR and LTR meat was observed for perceived acceptability; this was probably due to the comparable chemical composition and texture profile of meat from STR and LTR, as previously discussed. On the contrary, meat from STR showed a higher expected acceptability than meat from LTR (P < 0.001). In addition, the expected acceptability for STR meat was significantly higher than the liking expressed in blind conditions (P < 0.01), while the expected acceptability for LTR meat was significantly lower than the perceived acceptability (P < 0.05), thus indicating that a disconfirmation took place in both cases. In particular, consumers perceived meat from lambs STR worse than expected (negative disconfirmation); whereas, they found meat from lambs LTR better than expected (positive disconfirmation). Therefore, information about lamb geographical origin, transport duration, and welfare condition had a marked impact on consumer expectancy; indeed, meat from animals subjected to reduced transport stress with local origin were associated with high expected product quality.

Although no assimilation was observed in LTR lamb as no significant difference was detected between informed and perceived liking (blind acceptability) (P > 0.05), informed liking was higher for STR meat compared to perceived liking (P < 0.01): actual liking moved towards the expectations, thus demonstrating that the information on lamb geographical origin, transport duration, and welfare condition can affect the actual liking of the product. The effect of information can be explained on the basis of the assimilation model, as also shown in previous studies on consumers’ behaviour11,42, and consists in the shift of the informed liking of the product toward the direction of the expectations. In the present study, the information about geographical origin, transport duration, and welfare condition generated a positive impact on actual liking: the consumers assimilated their liking and they increased the actual acceptability towards the expectations. However, the assimilation was incomplete as a significant difference was detected between informed and actual liking (P < 0.05). This result is generally attributed to the role played by the sensory properties of the product in determining consumer acceptance. In a previous study, Napolitano et al.5 observed that a positive disconfirmation affected the informed liking, whereas

| Table 5. Effects of pre-slaughter short (STR) or long transport (LTR) on lamb pH, colour and mechanical properties (Least Squares means ± SEM). |
|-----------------------------------------|---------|---------|---------|---------|
| pH                                      | STR     | LTR     | SEM     | P-value |
| pH, 24 h                                | 6.59    | 6.34    | 0.05    | 0.003   |
| Lightness, L                            | 47.95   | 49.86   | 0.67    | 0.147   |
| Redness, a                              | 11.89   | 10.17   | 0.38    | 0.078   |
| Yellowness, b                           | 10.47   | 10.14   | 0.35    | 0.525   |
| Chroma, c                               | 15.72   | 14.62   | 0.52    | 0.146   |
| Hue angle, h                            | 41.90   | 44.27   | 1.07    | 0.128   |
| WBS, kg                                 | 5.86    | 5.54    | 0.19    | 0.244   |
| Hardness, kg                            | 4.95    | 5.03    | 0.24    | 0.182   |
| Choestiveness                           | 0.11    | 0.12    | 0.01    | 0.425   |
| Springiness, mm                         | 5.93    | 5.76    | 0.21    | 0.335   |
| Gumminess                               | 0.64    | 0.61    | 0.04    | 0.063   |
| Chewiness                               | 3.81    | 3.47    | 0.30    | 0.004   |

| Table 6. Rating (±SEM) given by the consumer panel during the three consumer/hedonic tests. |
|-----------------------------------------|---------|---------|---------|---------|
| Perceived liking (P)                    | STR     | LTR     | SEM     |
| Expected liking (E)                     | 6.85    | 6.64    | 0.16    |
| Informed liking (I)                     | 7.82a   | 6.28b   | 0.14    |
| P-E                                     | −1.34*** | 2.38*** | 0.22    |
| I-P                                     | 1.00*** | −0.37   | 0.22    |
| Assimilationa                           |         |         |         |
| I-E                                     | −0.36*  |         | 0.22    |
| Incompleteb                            |         |         |         |

a,b = P < 0.001. aThe product experience is worse than expected. bThe product is better than expected. cActual liking moves towards the expectations. dAssimilation occurs, but actual liking is lower than expectations.
a negative disconfirmation was unable to move the informed liking. In that study, the authors explained those
different results based on the type of information which concerned the rearing system of lambs. In particular, they
suggested that ewe-rearing was possibly considered the natural rearing conditions for lambs. In the present study,
we observed that a negative disconfirmation affected the informed liking, whereas a positive disconfirmation
was unable to affect the informed liking. Again, the consumers may perceive the importation of lambs, together
with low welfare e long transport information, as the most common market situation and be rather affected by
the positive information on the local origin of the product, higher welfare of the animals and consequently, short
transport duration.

In the last 20 years, animal welfare has been recognized for consumers as the most important component
of quality assurance of animal-based food. A number of important attributes for animal-based food are also
animal feeding, animal origin, food appearance and price. Napolitano et al. stated that if the meat is consid-
erered acceptable, in terms of sensory properties, the information about animal welfare can further increase meat
acceptability, allowing the consumers to gain a more positive perception of meat. In the present study, the origin
is confirmed to be an additional important extrinsic attribute that can influence the preferences of consumers,
and their food purchase decision-making. The effect of the origin information is recognised to play a central role
in affecting consumer decision of purchasing meat and meat products, and it is affected by the aspects related to
consumer’s beliefs, feelings or emotions, as suggested by Font-i-Furnols et al.

In the present study, the expectations due to the information on lamb geographical origin, transport duration,
and welfare condition, positively influenced consumers’ product acceptability. In particular, the preference for
meat derived from local lambs may be hypothesized to be associated with freshness, taste, quality and safety of the
lamb meat, and feeling confident that consumers place in the local productive enterprises.

Conclusion

Our results allow two main conclusions to be drawn. Firstly, long transport does not affect significant changes
in meat quality indicators, such as pH, colour, mechanical properties and chemical composition. Accordingly,
blood indicators reveal a response of adaptation to transport in terms of NEFA, CK, and white blood cells per-
centages, even if an increase of both haptoglobin and cortisol levels and a concomitant reduction of glucose level
are observed. Secondly, consumers are affected by the information concerning short transport, local origin of
lamb and good welfare moving their actual liking in the direction of expectancy. Therefore, the local production
of lamb may sustain animal welfare and concomitantly sustain the domestic market, if the provenance is appro-
priately communicated to the consumers.

Methods

Preliminary focus groups and food choice questionnaire. Thirty participants were recruited after
signing a consent form. The group consisted of 15 male and 15 female people with a mean age of 49.9 years. The
education level ranged from secondary school (20%), to high school diploma (47%) and graduation (33%). Focus
groups were conducted at the University of Basilicata in three different days with groups of 10 participants each
by the same trained moderator, a 40-year old, female consumer scientist with a specific background on the focus
and a decennial experience as focus group leader. A semi-structured questionnaire was followed in order to be
consistent across groups and, at the same time, allow for flexibility between groups. The discussion conducted in
each focus group was recorded and transcribed. Transcriptions were used to assess the perception of participants
of aspects affecting their lamb choice.

The food choice questionnaire was administered to 101 consumers of lamb (51 female and 50 male people)
with an education level ranging from secondary school (12%), to high school diploma (51%) and graduation
(37%), and reporting to consume this product at least once a year. They were informed by a trained consumer
about the aim of the study and the structure of the questionnaire, subsequently they filled the questionnaire
autonomously but they could ask for clarifications to the interviewer.

The first section of the questionnaire consisted of items concerning the socio demographic characteristics
of the consumers (gender, age, job category, education level), while the second section included items aimed at
investigating the main aspects affecting their lamb choice. These items were identified during the preliminary
focus groups. Each item was scored using a 7-point scale: from 1 = unimportant to 7 = very important.

Transport of lambs. All animal procedures were approved by the Foggia University Institutional Animal
Care and Use Committee (protocol number 003-2016) and were conducted under veterinary supervision. All
applicable international, national, and/or institutional guidelines for the care and use of animals were followed
(EU Directive 2010/63/EU). Thirty Merinos-derived male lambs were subjected to different transport distance
and slaughtered at Foggia (Southern of Italy). Fifteen lambs were subjected to a short transport duration (STR),
approximately around 1 h, starting from local farm to the slaughterhouse. A second group of fifteen lambs was
subjected to a long transport (LTR) according to the Regulation EC 1/2005, around 22 h going through 1250 km,
as long as the duration of transport from Bucharest (Romania) to the slaughterhouse located in Foggia. All of the
animals were weaned and reared in the same conditions, including the feeding regime based on a commercial
concentrate having 16% crude protein and 11.4 ME/kg dry matter/day and free access to hay. The available space
allowance was 0.32 m² per lamb, in compliance with the EC Regulation 1/2005. During LTR the animals received
water and straw ad libitum. At slaughterhouse, welfare issues (percentage of active animals, ambulatory animals,
injuries, lameness, dead), as resulting from transport of lambs, were monitored by veterinarian.

Animals were slaughtered at 60 ± 5 days of age, according to industrial routines used in Italy and to the EU
rule n. 1099/2009, after a lairage of approximately 12 hours with freely water availability and no access to feed.
Each carcass was weighed and chilled at 1–3 °C. After 24 h post-mortem carcasses were split into two sides. The left
side was used for meat quality measurements; *longissimus dorsi lumbarum* (LDL) muscle was removed, sampled
and then frozen at −20 °C. The right side was used for sensory analysis; LDL muscle was removed and was subsequently cut into steaks and then vacuum packed preserved at −20 °C until the day before panel evaluation.

**Determination of metabolic and immune indicators in plasma.** Before slaughtering blood samples from each animal were collected from the jugular vein in vacuum tubes with and without Na heparin. Both plasma and serum samples were centrifuged at 2500 rpm for 10 min at room temperature and stored at −20 °C. The right side was used for sensory analysis; LDL muscle was removed and was sub-

| Levels         | Number | Percentage |
|----------------|--------|------------|
| Age            |        |            |
| 18–25 years    | 13     | 15.8       |
| 26–35 years    | 28     | 34.2       |
| 36–45 years    | 16     | 19.5       |
| 46–55 years    | 25     | 30.5       |
| Sex            |        |            |
| Female         | 46     | 56.1       |
| Male           | 36     | 43.9       |
| Education level|        |            |
| High School    | 20     | 24.4       |
| Graduated      | 15     | 18.3       |
| Post-graduated | 47     | 57.3       |

Table 7. Socio-demographic features of the subjects participating to the consumer test.

**Meat mechanical properties.** After thawing at 4 °C, Warner–Bratzler shear force (WBSF) and texture profile analysis (TPA) were tested on cooked meat. Steak samples (2.0 cm of thickness) were grill-cooked at 270 °C to rich a core temperature of 70 °C. Both instrumental measurements were conducted using an Instron 3343 universal testing machine with a 500 N load cell (Instron Ltd., High Wycombe, United Kingdom) as previously described by della Malva et al.50.

**Meat chemical composition.** Each sample (50.0 g) was thawed and ground to homogenous consistency using a food processor. Moisture, protein, lipid and ash contents in each sample were determined according to AOAC methods51.

**Consumer test: perceived, expected and actual acceptability.** In order to setting up the consumer test, a number of 120 consumers were recruited in the city of Foggia (Apulia region, Southern Italy). All subjects were interviewed and were asked about their frequency of consumption of meat products at home (1 = never; 2 = once a year or less; 3 = 3–5 times a year; 4 = less than once a month; 5 = 1–2 times a month; 6 = more than 2 times a month; 7 = once a week). Eighty-two consumers were selected using predetermined screening criteria based on consumption of meat products with a frequency of at least once a month. In addition, consumers completed a form with personal data according to Napolitano et al.9. The main features of consumers are depicted in Table 7.

The samples were thawed at 4 °C 24 h prior to evaluation. At the panel day, meat samples (3 × 3 × 2 cm, mean weight 50.3–55.6 g) were grilled (Maxima Grill electric MGRILL BIG) at 300 °C to an internal temperature of 75 °C assessed using a thermocouple probe inserted into the meat for about 12 min as described by Napolitano et al.9. Meat samples were offered to the subjects immediately after cooking.
The assessment of meat acceptability was planned in three tests according to Napolitano et al. In the first test, the consumers were offered meat samples from lambs subjected to short and long transport time in a random codified order of samples presentation directly in the plate. They were asked to taste the meat and rate their liking receiving no information on the products (Blind acceptability). In the second test, the subjects received a sheet with the information concerning the transport duration and its effect on animal welfare. They were asked to read carefully the information and give their liking expectation for that product (Expected acceptability). First and second tests were performed in the same day.

The third test was performed on the next day: the consumers were given meat from both STR and LTR group along with the information sheet. The consumers were instructed to read the information before tasting samples and express their liking score (Informed acceptability). Consumers rated their liking on a nine-point hedonic scale labelled at the left end with “extremely unpleasant”, at the right end with “extremely pleasant” and at the central point with “neither pleasant nor unpleasant”.

In tests second (expectations produced by information) and third (acceptability generated by information and tasting of the product) the following information concerning the duration of transport and its effects on animal welfare were given to consumers:

1. STR: meat from local lambs subjected to a short transport time before slaughtering with a low impact on animal welfare.
2. LTR: meat from imported lambs subjected to a long transport time before slaughtering with an important impact on animal welfare.

In both days, for each session, eighty-two consumers were divided into groups and each animal from STR and LTR group was tested at least by 3 consumers. All meat from each animal and experimental group was tested.

**Statistical analysis.** Nutritional, textural and quantitative descriptive sensory data were tested for normality using the Shapiro–Wilk test; then, data were processed by ANOVA using the GLM procedure of SAS. When significant effects were found (at $P < 0.05$), the Student t-test was used to locate significant differences between means.

The analysis of variance was carried out using the MIXED procedure of the SAS system for consumer panel test using the information condition: perceived (P), expected (E) and informed (I) liking, as fixed effect; whereas, consumers were included as random effect. To evaluate the effect of information on the consumer’s acceptability, the difference between perceived liking score and expected liking score (P-E) as well as differences between informed and perceived liking scores (I-P) and informed and expected liking scores (I-E) were calculated. Then, the Paired t-tests were performed in order to establish if those differences were significantly different from zero.

Received: 29 November 2019; Accepted: 4 May 2020; Published online: 16 June 2020

**References**

1. Herleth, M., Næs, T., Redbotten, M. & Monteleone, E. Lamb meat-Importance of origin and grazing system for Italian and Norwegian consumers. *Meat Sci.* 90, 899–907 (2012).
2. Bernuéñez, A., Olazola, A. & Corcoran, K. Labelling information demanded by European consumers and relationships with purchasing motives, quality and safety of meat. *Meat Sci.* 65, 1095–1106 (2003).
3. Bernabéu, R., Rabadán, A., El Orche, N. E. & Díaz, M. Influence of quality labels on the formation of preferences of lamb meat consumers. A Spanish case study. *Meat Sci.* 135, 129–133 (2018).
4. Van der Lans, J. A., van Ittersum, K., De Cicco, A. & Loseby, M. The role of the region of origin and EU certificates of origin in consumer evaluation of food products. *Eur. Rev. Agric. Econ.* 28(4), 451–477 (2001).
5. Jordan, J. Traditional foods: Challenges facing the European food industry. *Food Res. Int.* 33(3–4), 147–152 (2000).
6. Marino, R. et al. “Consumers’ expectations and acceptability for low saturated fat “salami”: healthiness or taste?”. *J. Sci. Food Agric.* 97(11), 3513–3521 (2017).
7. Guerero, L. et al. Consumer-driven definition of traditional food products and innovation in traditional foods. A qualitative cross-cultural study. *Appetite* 52(2), 345–354 (2009).
8. Sánchez, C. et al. Regional variation in the hedonic evaluation of lamb meat from diverse production systems by consumers in six European countries. *Meat Sci.* 75, 610–621 (2007).
9. Napolitano, F. et al. Effect of information about animal welfare, expressed in terms of rearing conditions, on lamb acceptability. *Meat Sci.* 77, 431–436 (2007).
10. Boutonnet, J. P. Perspectives of the sheep meat world market on future production systems and trends. *Small Rumin. Res.* 34, 185–195 (1999).
11. Broom, D. M. Indicators of poor welfare. *Br. Vet. J.* 142, 524–526 (1986).
12. Broom, D. M. The scientific assessment of animal welfare. *Appl. Anim. Behav. Sci.* 20, 5–19 (1988).
13. Miranda-de la Lama, G. C. et al. Effects of road type during transport on lamb welfare and meat quality in dry hot climates. *Trop. Anim. Health Prod.* 43, 915–922 (2011).
14. Adenekola, A. Y. & Ayo, J. O. Physiological and behavioural responses of livestock to road transportation stress: A review. *Afr. J. Biotechnol.* 9(31), 4845–4856 (2010).
15. Dalmasso, A. et al. Effects of the duration of road transport on the physiology and meat quality of lambs. *Anim. Prod. Sci.* 54, 179–186 (2014).
16. Swanson, J. C. & Morrow-Tesch, J. Cattle transport: Historical, research, and future perspectives. *J. Anim. Sci.* 79(suppl_E), E102–E109 (2001).
17. Sanjuán-López, A. I., Philippides, G. & Resano-Ecarrar, H. How useful is acceptability to explain economic value? An application on the introduction of innovative saffron products into commercial markets. *Food Qual. Prefer.* 22, 255–263 (2011).
18. Braghiari, A., Pizzazolla, N., Carlucci, A., Bragaglio, A. & Napolitano, F. Sensory properties, consumer liking and choice determinants of Lucanian dry cured sausages. *Meat Sci.* 111, 122–129 (2016).
19. Moskowitz, H. R. Food quality: conceptual and sensory aspects. *Food Qual. Prefer.* 6(3), 157–162 (1995).
50. della Malva, A.

49. Liu, Q., Scheller, K. K., Arp, S. C., Schaefer, D. M. & Frigg, M. Color coordinates for assessment of dietary vitamin E effects on beef

45. Font-i-Furnols, M. & Guerrero, L. Consumer preference, behaviour and perception about meat and meat products. An overview.

46. Krueger, R. A. Moderating focus groups. Thousand Oaks, CA: Sage. (1998).

47. Krueger, R. A. Analyzing and reporting focus group results. Thousand Oaks, CA: Sage. (1998).

48. Steptoe, A. & Pollard, T. M. Development of a measure of the motives underlying the selection of food: the food choice questionnaire.

44. Davidson, A., Schröder, M. J. A. & Bower, J. A. The importance of origin as a quality attribute for beef, results from a Scottish

54. SAS 2011. SAS/STAT User's Guide (Version 9.2). Statistical Analysis System Inst, Cary, NC.

55. Lange, C., Rousseau, F. & Issanchou, S. Expectation, liking and purchase behaviour under economical constraint.

41. Cardello, A. V. & Sawyer, F. M. Effects of disconfirmed consumer expectations on food acceptance.

43. Montossi, F.

40. Devine, C. E.

39. Marino, R.

36. Hall, S. J. G., Broom, D. M. & Kiddy, G. N. S. Effect of transportation on plasma cortisol and packed cell volume in different genotypes of sheep.

32. Knowles, T. & Warriss, P. Stress physiology of animals during transport. In Livestock Handling and Transport (ed. Grandin, T.) (Ed.), 312–328 (CABI, 2007).

33. Zhong, R. Z., Liu, H. W., Zhou, D. W., Sun, H. X. & Zhao, C. S. The effects of road transportation on physiological responses and meat quality of sheep suffering in age. J. Anim. Sci. 89, 3742–3751 (2011).

34. De la Fuente, J. et al. Physiological response and carcass and meat quality of suckling lambs in relation to transport time and stocking density during transport by road. Animal 4(2), 250–258 (2010).

35. Miranda-de la Lama, G. C. et al. Effect of the pre-slaughter logistic chain on some indicators of welfare in lambs. Livest. Sci. 128, 52–59 (2010).

36. Hall, S. J. G., Broom, D. M. & Kiddy, G. N. S. Effect of transportation on plasma cortisol and packed cell volume in different genotypes of sheep. Small Rumin. Res. 29, 233–237 (1998).

37. Pritchard, J. C., Barr, A. R. S. & Whay, H. R. Validity of a behavioural measure of heat stress and a skin tent test for dehydration in working horses and donkeys. Equine Vet. J. 38, 433–438 (2010).

38. Leperd, M. L., Canfield, P. J., Hunt, G. B. & Bowdaw, K. L. Haematological, biochemical and selected acute phase protein reference intervals for weaned female Merino lambs. Austr. J. Biol. Sci. 52(3), 531–541 (2012).

39. Marino, R. et al. Effect of quinina on meat quality and/or linseed on immune response, productivity and quality of meat from merinos derived lambs. Animals 8(11), 204–2011 (2018).

40. Devine, C. E. et al. Pre-slaughter stress arising from on-farm handling and its interactions with electrical stimulation on tenderness of lamb. Meat Sci. 73, 304–312 (2006).

41. Cardello, A. V. & Sawyer, F. M. Effects of disconfirmed consumer expectations on food acceptance. J Sens Stud 7, 253–277 (1992).

42. Morales, R., Aguia, J. P. S., Subiache, I. & Realini, C. E. Beef acceptability and consumer expectations associated with production systemand marbling. Food Qual. Prefer. 29, 166–173 (2013).

43. Montossi, F. et al. Sustainable sheep production and consumer preference trends: Contradictions, compatibilities, and unresolved dilemmas. Meat Sci. 95(4), 772–789 (2013).

44. Davidson, A., Schröder, M. J. A. & Bower, J. A. The importance of origin as a quality attribute for beef, results from a Scottish consumer survey. Int. J Consum. Stud. 27, 91–98 (2003).

45. Font-i-Furnols, M. & Guerrero, L. Consumer preference, behaviour and perception about meat and meat products. An overview. Meat Sci. 98, 361–371 (2014).

46. Krueger, R. A. Moderating focus groups. Thousand Oaks, CA: Sage. (1998).

47. Krueger, R. A. Analyzing and reporting focus group results. Thousand Oaks, CA: Sage. (1998).

48. Steptoe, A. & Pollard, T. M. Development of a measure of the motives underlying the selection of food: the food choice questionnaire. Appetite 25, 267–284 (1995).

49. Liu, Q., Scheller, K. K., Arp, S. C., Schaefer, D. M. & Frigg, M. Color coordinates for assessment of dietary vitamin E effects on beef color stability. J. Anim. Sci. 74(1), 106–116 (1996).

50. della Malva, A. et al. Proteomic approach to investigate the impact of different dietary supplementation on lamb meat tenderness. Meat Sci. 131, 74–81 (2017).

51. AOAC methods. Official methods of analysis. Association of Official Analytical Chemists (1995).

52. Kähkönen, P., Tuorila, H. & Ritala, H. How information enhances acceptability of a low-fat spread. Food Qual. Pref. 7, 87–94 (1996).

53. Shapiro, S. S. & Wilk, M. B. An analysis of variance test for normality. Biometrika 52, 591–601 (1965).

54. SAS 2011. SAS/STAT User’s Guide (Version 9.2). Statistical Analysis System Inst, Cary, NC.

55. Lange, C., Rousseau, F. & Issanchou, S. Expectation, liking and purchase behaviour under economical constraint. Food Qual. Prefer. 10, 21–39 (1999).

Acknowledgements
The research was funded by Fondazione Banca del Monte, Foggia, Italy.

Author contributions
M.C. and M.A. conceived the study and designed the research plan; M.G.C. and A.B. performed the experiments; F.N. and R.M. analyzed the data; M.A., F.N., A.B., R.M., A.S. and M.G.C. draft the manuscript that was revised by M.C. and A.S.; all Authors revised and approved the final version of manuscript.

Competing interests
The authors declare no competing interests.

Additional information
Correspondence and requests for materials should be addressed to M.C.
